NRC's Level 3 PRA (Offsite Consequence Analysis) Status

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Outline

- Documentation Development
- Technical Element Status
- Consequence Reporting Considerations

Documentation Format

- Development of standard format and content based on review of prior studies
- Uses MACCS input parameters, organized according to Technical Analysis Approach plan (TAAP) technical elements, to structure qualitative discussion
- Individual volumes for each scope piece (e.g., reactor, at-power, internal events and floods)
- Each volume based on scope-piece-specific updates to initial volume

CONTENTS

Input Parameter Documentation

- Technical Discussion
  - MACCS conceptual model description based on MACCS model description documents (NUREG/CR-4691 Vol 2 and NUREG/CR-6613 Vol 1)
  - Discussion of technical bases for input parameters reflecting state of practice analysis
  - Technical bases drawn from site specific information and best practice recommendations documented in draft NUREG/CR-7009
- Tabular summary of input parameters
  - References to applicable discussion section for traceability
- Quality assurance discussion
  - Based on high-level and supporting requirements from draft Level 3 PRA standard
  - Include discussion of parameter and model uncertainties informed by SOARCA Peach Bottom Uncertainty Analysis

Technical Element Status

- Transition from the Radionuclide Release to Level 3 (RE)
  - MELMACCS development efforts for generation of composite sources for multisource releases
  - Coordination with Level 2 analyses for release category binning and representative source term development
- Meteorological Data (ME)
  - 1998-2002 meteorological data available from Vogtle early site permit (ESP) application
  - Extensive discussion of site meteorology from ESP environmental report and environmental impact statement
  - MACCS2 meteorological file to be reviewed by NRC staff meteorologists
- Atmospheric Transport and Dispersion (ATD)
  - Atmospheric modeling consistent with current best practice recommendations
  - Review of site-specific conditions to facilitate qualitative evaluation of model results

Technical Element Status (continued)

- Protective Action Parameters and Other Site Data (PA)
  - Based on work underway at Sandia National Laboratories (SNL)
  - Updated version of SECPOP available based on 2010 census data
  - Site demographic characteristics based on 2010 census data supplemented by information from site visits
  - Three standard evacuation models developed; detailed parameterization will be updated when source term data is available
  - Relocation, interdiction and decontamination models based on best practice default values
  - Leverage ongoing SNL work on updating decontamination plan data
- Economic Factors (EC)
  - Based on updated 2007 BEA and USDA databases in SECPOP and best practice default values for non-site-specific parameters

Technical Element Status (continued)

- Dosimetry (DO)
  - Dosimetry based on dose conversion factor files developed for SOARCA
  - Consistent with FGR-13 and recommendations by K. Eckermann
- Health Effects (HE)
  - Health effects models for acute and stochastic effects based on recommended best practices parameters
  - Acute early fatality parameters consistent with 1997 expert elicitation
  - Latent effects data consistent with BEIR V for consistency with dose conversion factor files
  - Latent health effects model to include dose-response models consistent with both linear no-threshold (LNT) and Health Physics Society (HPS) position statement

Consequence Reporting

- Reflects Quantification and Reporting (QT) and Risk Integration (RI) sections of TAAP
- Input parameter development based on consequence measures selected for reporting
- Consequence reporting considerations informed by review of
  - MACCS2 output capabilities
  - Consequence analysis applications
  - Past studies

MACCS Output Capabilities
Output Measures

- Concentration of individual radionuclides in air (Bq/m^3) and on ground surface (Bq/m^2)
- Dosimetric measures for individuals and populations by organ and for whole body
- Dose contributions to population dose by dose pathway, accident phase, and for individual cohorts.
- Collective and individual health effects resulting from accumulated doses
- Extent of land area and population affected by radionuclide deposition and/or protective measures
- Costs associated with protective measures

MACCS2 Output Capabilities
Output Format

- MACCS2 results computed on a radial spatial grid (e.g., 64 sectors x 26 radii = 1664 grid elements)
- Results computed for each weather trial (e.g., ~1000 weather trials to cover multiple meteorological bins defined by windspeed, stability class, and precipitation)
- Depending upon the selected measure, computational results can be:
  - Averaged over all weather trials or reported as a distribution across weather trials
  - Reported at a specified grid element
  - Integrated over a user defined radial region (e.g., 0-10 miles, 40-50 mile ring, etc.)
  - Normalized by the population in the user-defined region to yield an average individual risk in that region (e.g., latent cancer fatality risk within 10 miles)

Consequence Reporting
Applications

- Risk-informed decisionmaking (RG 1.174)
- Regulatory Analysis (NUREG/BR-0058 and NUREG/BR-0184)
- Backfit Analysis (NUREG-1409)
- Environmental Reviews (NUREG-1555)
  - Section 7.2: Severe Accidents
  - Section 7.3: Severe Accident Mitigation Alternatives

Applications

Summary of Output Measures

	Ind. Early Fatality Risk	Ind. Latent Fatality Risk	Collective Dose Risk	Offsite Property Damage Risk	Total Early Fatality Risk	Total Latent Fatality Risk	Land Contam. Risk
Risk-Informed Decisionmaking	X	X					
Backfit Analysis	X	X	X				
Regulatory Analysis	X	X	X	X			
Severe Accident Mitigation Alternatives			X	X			
Severe Accident Environmental Assessment	X	X	X	X	X	X	X

Consequence Reporting
Review of Past Studies

- CRAC/WASH-1400 (ca. 1975-1985)
  - WASH-1400 (*Reactor Safety Study*)
  - NUREG/CR-2239 (*Siting Study*)
  - NUREG/CR-2723 (*Strip Report*)

- MACCS/NUREG-1150 (ca. 1985-2000)
  - NUREG-1150 (*Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants*)
  - NUREG/CR-4551 Volumes 3-7 (*Plant-specific detailed reports supporting NUREG-1150*)
  - NUREG-5305 (*Integrated Risk Assessment for the LaSalle Unit 2 Nuclear Power Plant*)
  - NUREG/CR-6349 (*Cost-Benefit Considerations in Regulatory Analysis*)

- MACCS2/SOARCA (ca. 2000 – present)
  - NUREG-1935 (*State of the Art Reactor Consequence Analysis*)
  - NUREG/CR-7110 Volumes 1 and 2 (*Plant-specific detailed reports supporting SOARCA*)

Review of Past Studies

Summary of Output Measures

	Dosimetric		Health Effects				Social/Economic	
Report	Organ Dose	Collective Dose	Early Fatalities	Early Injuries	Latent Fatalities	Latent Injuries	Land Contam.	Economic Cost
NUREG-75/014 (WASH-1400)	IND*		TOT IND	TOT IND	TOT IND	TOT IND	TOT	TOT
NUREG/CR-2239	IND		TOT IND	TOT	TOT IND	TOT	TOT	
NUREG/CR-2723		TOT	TOT	TOT	TOT			TOT
NUREG-1150 NUREG/CR-4551 NUREG/CR-5305		TOT	TOT IND		TOT IND			TOT**
NUREG/CR-6349		TOT	TOT		TOT			TOT
NUREG-1935, NUREG/CR-7110			IND		IND			

TOT: Total health effects cases or cumulative amount; IND: Individual risk of health effect

*Detailed organ dose results presented in explanatory sections in Appendix VI

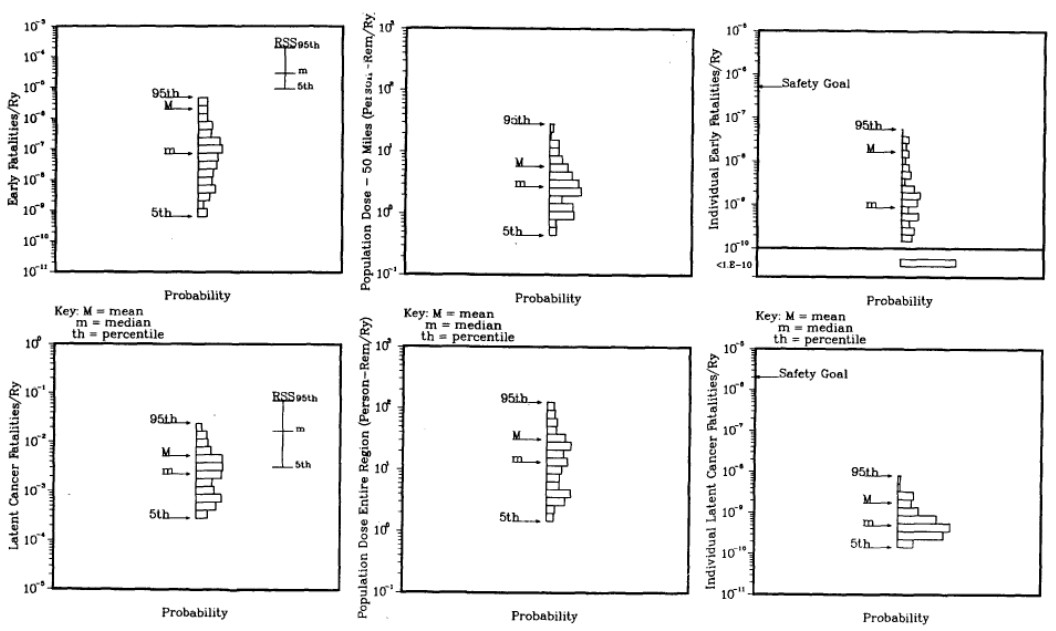
** Property damage results presented in supplemental tables in appendices to NUREG/CR-4551

Historically Reported Metrics

NUREG-1150 Supporting Analyses

Table 4.3-1
Mean Consequence Results for Internal Initiators
(Population Doses in Sv)

Source Term	Early Fatalities	Total Lat. Cancer Fatalities	Pop. Dose Within 50 mi	Pop. Dose Entire Region	Individual Early Fat. Risk, 1 mi.	Individual Lat. Can. Fatality Fat. Risk 10 mi.
SUR-01-1	-----	-----	-----	-----	-----	-----
SUR-01-2	9.35E-5	9.31E+1	2.33E+3	5.73E+3	4.64E-6	6.52E-5
SUR-01-3	3.87E-2	3.90E+1	1.24E+3	2.24E+3	1.31E-3	1.42E-4
SUR-02-1	5.70E-4	2.43E+2	5.22E+3	1.46E+4	2.45E-5	8.38E-5
SUR-02-2	5.68E-1	7.67E+2	1.13E+4	4.42E+4	3.82E-3	1.48E-3
SUR-02-3	4.94E-2	2.72E+2	5.82E+3	1.61E+4	1.65E-3	2.28E-4
SUR-03-1	1.16E-2	6.89E+2	1.15E+4	4.19E+4	1.60E-4	1.12E-4
SUR-03-2	4.20E-1	1.59E+3	2.26E+4	9.60E+4	4.51E-3	1.34E-3
SUR-03-3	1.57E-1	7.94E+2	1.13E+4	4.78E+4	4.37E-3	3.62E-4
SUR-04-1	6.80E-4	1.04E+3	1.04E+4	6.13E+4	2.59E-5	1.17E-4
SUR-04-2	2.11E-4	9.37E+2	1.45E+4	5.55E+4	1.02E-5	2.86E-4
SUR-04-3	-----	-----	-----	-----	-----	-----
SUR-05-1	-----	-----	-----	-----	-----	-----
SUR-05-2	2.86E+0	3.61E+3	5.15E+4	1.92E+5	2.97E-2	3.99E-3
SUR-05-3	1.83E+0	2.56E+3	2.62E+4	1.58E+5	1.60E-2	8.91E-4
SUR-06-1	-----	-----	-----	-----	-----	-----
SUR-06-2	9.24E-2	2.42E+3	2.42E+4	1.44E+5	2.16E-3	7.47E-4
SUR-06-3	1.49E+0	2.19E+3	2.15E+4	1.32E+5	1.34E-2	9.67E-4
SUR-07-1	6.55E-2	2.38E+3	2.76E+4	1.42E+5	1.96E-4	1.13E-4
SUR-07-2	3.38E+0	2.83E+3	3.43E+4	1.67E+5	3.73E-2	2.72E-3
SUR-07-3	5.03E-1	1.40E+3	1.46E+4	8.30E+4	8.97E-3	5.96E-4
SUR-08-1	7.75E-3	2.20E+3	1.68E+4	1.31E+5	1.09E-4	1.32E-4
SUR-08-2	2.64E-2	2.27E+3	2.14E+4	1.34E+5	1.22E-3	3.72E-4
SUR-08-3	2.35E-1	1.44E+3	1.61E+4	8.43E+4	5.57E-3	5.11E-4
SUR-09-1	3.08E-3	1.66E+3	1.36E+4	9.83E+4	6.75E-5	1.21E-4
SUR-09-2	1.97E-3	1.35E+3	1.74E+4	7.97E+4	6.00E-5	3.06E-4
SUR-09-3	-----	-----	-----	-----	-----	-----



Historically Reported Metrics

NUREG/CR-6349

- *Cost Benefit Considerations in Regulatory Analysis*
- Tabulated values for
  - Early Fatalities
  - Latent Fatalities
  - Population dose
  - Offsite Economic Costs
- Tables for
  - each NUREG-1150 plant
  - 10, 50, 100, and 1000 miles

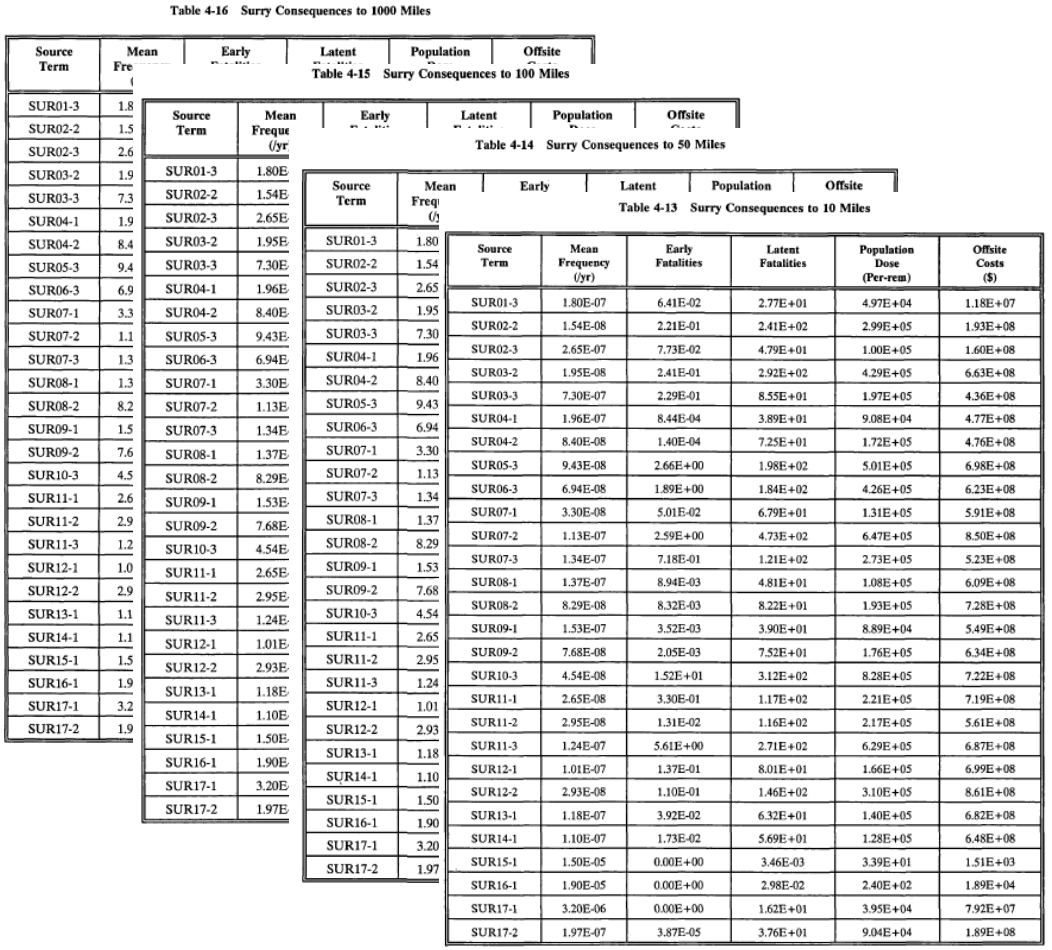


Table 4-16 Surry Consequences to 1000 Miles

Source Term	Mean Fre	Early	Latent	Population	Offsite
SUR01-3	1.8				
SUR02-2	1.5				
SUR02-3	2.6				
SUR03-2	1.9				
SUR03-3	7.3				
SUR04-1	1.9				
SUR04-2	8.4				
SUR05-3	9.4				
SUR06-3	6.9				
SUR07-1	3.3				
SUR07-2	1.1				
SUR07-3	1.3				
SUR08-1	1.3				
SUR08-2	8.2				
SUR09-1	1.5				
SUR09-2	7.6				
SUR10-3	4.5				
SUR11-1	2.6				
SUR11-2	2.9				
SUR11-3	1.2				
SUR12-1	1.0				
SUR12-2	2.9				
SUR13-1	1.1				
SUR14-1	1.1				
SUR15-1	1.5				
SUR16-1	1.9				
SUR17-1	3.2				
SUR17-2	1.9				

Table 4-15 Surry Consequences to 100 Miles

Source Term	Mean Freque (/yr	Early	Latent	Population	Offsite
SUR01-3	1.80E				
SUR02-2	1.54E				
SUR02-3	2.65E				
SUR03-2	1.95E				
SUR03-3	7.30E				
SUR04-1	1.96E				
SUR04-2	8.40E				
SUR05-3	9.43E				
SUR06-3	6.94E				
SUR07-1	3.30E				
SUR07-2	1.13E				
SUR07-3	1.34E				
SUR08-1	1.37E				
SUR08-2	8.29E				
SUR09-1	1.53E				
SUR09-2	7.68E				
SUR10-3	4.54E				
SUR11-1	2.65E				
SUR11-2	2.95E				
SUR11-3	1.24E				
SUR12-1	1.01E				
SUR12-2	2.93E				
SUR13-1	1.18E				
SUR14-1	1.10E				
SUR15-1	1.50E				
SUR16-1	1.90E				
SUR17-1	3.20E				
SUR17-2	1.97E				

Table 4-14 Surry Consequences to 50 Miles

Source Term	Mean Freq (/	Early	Latent	Population	Offsite
SUR01-3	1.80				
SUR02-2	1.54				
SUR02-3	2.65				
SUR03-2	1.95				
SUR03-3	7.30				
SUR04-1	1.96				
SUR04-2	8.40				
SUR05-3	9.43				
SUR06-3	6.94				
SUR07-1	3.30				
SUR07-2	1.13				
SUR07-3	1.34				
SUR08-1	1.37				
SUR08-2	8.29				
SUR09-1	1.53				
SUR09-2	7.68				
SUR10-3	4.54				
SUR11-1	2.65				
SUR11-2	2.95				
SUR11-3	1.24				
SUR12-1	1.01				
SUR12-2	2.93				
SUR13-1	1.18				
SUR14-1	1.10				
SUR15-1	1.50				
SUR16-1	1.90				
SUR17-1	3.20				
SUR17-2	1.97				

Table 4-13 Surry Consequences to 10 Miles

Source Term	Mean Frequency (/yr)	Early Fatalities	Latent Fatalities	Population Dose (Per-rem)	Offsite Costs ($)
SUR01-3	1.80E-07	6.41E-02	2.77E+01	4.97E+04	1.18E+07
SUR02-2	1.54E-08	2.21E-01	2.41E+02	2.99E+05	1.93E+08
SUR02-3	2.65E-07	7.73E-02	4.79E+01	1.00E+05	1.60E+08
SUR03-2	1.95E-08	2.41E-01	2.92E+02	4.29E+05	6.63E+08
SUR03-3	7.30E-07	2.29E-01	8.55E+01	1.97E+05	4.36E+08
SUR04-1	1.96E-07	8.44E-04	3.89E+01	9.08E+04	4.77E+08
SUR04-2	8.40E-08	1.40E-04	7.25E+01	1.72E+05	4.76E+08
SUR05-3	9.43E-08	2.66E+00	1.98E+02	5.01E+05	6.98E+08
SUR06-3	6.94E-08	1.89E+00	1.84E+02	4.26E+05	6.23E+08
SUR07-1	3.30E-08	5.01E-02	6.79E+01	1.31E+05	5.91E+08
SUR07-2	1.13E-07	2.59E+00	4.73E+02	6.47E+05	8.50E+08
SUR07-3	1.34E-07	7.18E-01	1.21E+02	2.73E+05	5.23E+08
SUR08-1	1.37E-07	8.94E-03	4.81E+01	1.08E+05	6.09E+08
SUR08-2	8.29E-08	8.32E-03	8.22E+01	1.93E+05	7.28E+08
SUR09-1	1.53E-07	3.52E-03	3.90E+01	8.89E+04	5.49E+08
SUR09-2	7.68E-08	2.05E-03	7.52E+01	1.76E+05	6.34E+08
SUR10-3	4.54E-08	1.52E+01	3.12E+02	8.28E+05	7.22E+08
SUR11-1	2.65E-08	3.30E-01	1.17E+02	2.21E+05	7.19E+08
SUR11-2	2.95E-08	1.31E-02	1.16E+02	2.17E+05	5.61E+08
SUR11-3	1.24E-07	5.61E+00	2.71E+02	6.29E+05	6.87E+08
SUR12-1	1.01E-07	1.37E-01	8.01E+01	1.66E+05	6.99E+08
SUR12-2	2.93E-08	1.10E-01	1.46E+02	3.10E+05	8.61E+08
SUR13-1	1.18E-07	3.92E-02	6.32E+01	1.40E+05	6.82E+08
SUR14-1	1.10E-07	1.73E-02	5.69E+01	1.28E+05	6.48E+08
SUR15-1	1.50E-05	0.00E+00	3.46E-03	3.39E+01	1.51E+03
SUR16-1	1.90E-05	0.00E+00	2.98E-02	2.40E+02	1.89E+04
SUR17-1	3.20E-06	0.00E+00	1.62E+01	3.95E+04	7.92E+07
SUR17-2	1.97E-07	3.87E-05	3.76E+01	9.04E+04	1.89E+08

Review of Past Studies
Observations

- A wide variety of output metrics have been reported in past studies
- Output metrics have been reported at a range of distances
- Level of detail of reported metrics dependent upon document hierarchy
- MACCS2 analyses produce conditional consequences for each representative source term/release category
- Results tabulated for use by risk integration team

Summary

- Consistent, structured document format and content facilitates traceability and transparency for both technical review and future use
- Consequence metrics analyzed in past studies have varied but have generally included both individual health impacts, societal health impacts, and measures of economic/property damage
- High level summary reports have generally been supplemented by supporting or supplemental reports with additional metrics and details

Selected References (1/2)

- WASH-1400 (*Reactor Safety Study*)
- NUREG/CR-2239 (*Siting Study*)
- NUREG/CR-2723 (*Strip Report*)
- NUREG-1150 (*Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants*)
- NUREG/CR-4551 Volume 2 Part 7 (*Quantification of Major Input Parameters supporting NUREG-1150, MACCS Input*)
- NUREG/CR-4551 Volumes 3-7 (*Plant-specific detailed reports supporting NUREG-1150*)
- NUREG-5305 (*Integrated Risk Assessment for the LaSalle Unit 2 Nuclear Power Plant*)
- NUREG/CR-6349 (*Cost-Benefit Considerations in Regulatory Analysis*)
- NUREG-1935 (*State of the Art Reactor Consequence Analysis*)
- NUREG/CR-7110 Volumes 1 and 2 (*Plant-specific detailed reports supporting SOARCA*)

Selected References (2/2)

- NUREG/CR-4691 Volume 2 (*MACCS Model Description Document*)
- NUREG/CR-6613 Volume 1 (*MACCS2 Model Description Document*)
- NUREG/CR-7009 (*Best Practices from State of theArt Reactor Consequence Analyses Study*), unpublished draft
- Regulatory Guide 1.174 (*An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis*)
- NUREG/BR-0058 (*Regulatory Analysis Guidelines*)
- NUREG/BR-0184 (*Regulatory Analysis Handbook*)
- NUREG-1409 (*Backfitting Guidelines*)
- NUREG-1555 (*Environmental Standard Review Plan*)

Preliminary Listing of Potential Technical Basis Documents for Offsite Consequence Analyses

(note: NUREG-(nnnn) designates publications prepared by NRC staff; NUREG/CR-(nnnn) designates publications prepared by NRC contractors)

General Applicability

- NUREG-75/014, Appendix VI (*Calculation of Reactor Accident Consequences: Appendix VI to Reactor Safety Study*), 1975
- NUREG/CR-2300 (*PRA Procedures Guide - A Guide to the Performance of Probabilistic R isk Assessments for Nuclear Power Plants*), 1983
- NUREG/CR-3332 (*Radiological Assessment: A Textbook on Environmental Dose Analysis*), 1983
- NUREG/CR-4350 Volume 7 (*Probabilistic Risk Assessment Course Documentation Volume 7: Environmental Transport and Consequence Analysis*), 1985
- NUREG/CR-4551 Volume 2 Part 7 (*Evaluation of Severe Accident Risks: Quantification of Major Input Parameters*), 1990
- NUREG-0340 (*Overview of the Reactor Safety Study Consequence Model*), 1977
- NUREG/CR-4691 (*MELCOR Accident Consequence Code System, 3 volumes*), 1990
- NUREG/CR-6613 (*Code Manual for MACCS2, 2 volumes*), 1997-1998
- NUREG/CR-6042 Rev 2 (*Perspectives on Reactor Safety*), 2002

RE

- NUREG/CR-4467 (*Relative Importance of Individual Elements to Reactor Accident Consequences Assuming Equal Release Fractions*), 1986
- NUREG-1465 (*Accident Source Terms for Light-Water Nuclear Power Plants*), 1995
- NUREG/CR-6119 (*MELCOR Computer Code Manuals*), 2000-2001
- SAND2008-6664 (*Accident Source Terms for Pressurized Water Reactors with High Burnup Cores Calculated using MELCOR 1.8.5), 2008*
- ORNL/TM-2005/39 (*SCALE: A Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluations – Version 5.1, Volumes I – III*), 2006
- MELMACCS Documentation (TBD)

ME/AT

- DOE/TIC-11223 *("Handbook on Atmospheric Diffusion," Hanna, S.R., G.A. Briggs, and R.P. Hosker, Jr,*) 1982
- DOE/TIC-27601 (*"Plume Rise and Buoyancy Effects," Briggs, G.A.*), 1984
- DOE/TIC-27601; DE84005177 (*"Atmospheric Science and Power Production, D. Randerson, ed.*) 1984
- NUREG/CR-6331 Rev 1(*Atmospheric Relative Concentrations in Building Wakes*), 1997
- Regulatory Guide 1.23 Rev 1 (*Meteorological Monitoring Programs for Nuclear Power Plants*)
- Regulatory Guide 1.145 Rev 1 (*Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants*)
- Atkinson, D. and R.F. Lee, "Procedures for Substituting Values for Missing NWS Meteorological Data for Use in Regulatory Air Quality Models," 1992
- NUREG/CR-4159 (*Comparison of the 1981 INEL Dispersion Data with Results from a Number of Different Models*), 1985
- NUREG/CR-6853 (*Comparison of Average Transport and Dispersion Among a Gaussian, a Two-Dimensional, and a Three-Dimensional Model*), 2004

PA/EC

- NUREG/CR-6525 Rev 1 (*SECPOP2000: Sector Population, Land Fraction, and Economic Estimation Program*), 2003
- NUREG-0396 (*Planning Basis For The Development Of State And Local Government Radiological Emergency Response Plans In Support Of Light Water Nuclear Power Plants),* 1978
- NUREG-0654/FEMA-REP-1 Rev 1 (*Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants*.), 1980-2011
- NUREG/CR-6953 (*Review of NUREG-0654, Supplement 3, "Criteria for Protective Action Recommendations for Severe Accidents*), 2007
- Update to Supplement 3 to NUREG 0654/FEMA-REP-1, Rev. 1, (*Criteria for Protective Action Recommendations for Severe Accidents*), 2010
- NUREG/CR-4831 (*State of the Art in Evacuation Time Estimate Studies for Nuclear Power Plants*), 1992
- NUREG/CR-6864 (*Identification and Analysis of Factors Affecting Emergency Evacuations*), 2005
- NUREG/CR-7002 (*Criteria for Development of Evacuation time Estimate Studies*), 2011
- EPA-400-R-92-001 (*Manual of Protective Action Guides and Protective Actions for Nuclear Incidents*), 1992
- SAND2000-2719/1 (*Cassini Spacecraft Uncertainty Analysis Data and Methodology Review and Update Volume 1: Updated Parameter Uncertainty Models for the Consequence Analysis)*, 2000
- NUREG/CR-2591 (*Estimating the Potential Impacts of a Nuclear Reactor Accident*), 1982
- NUREG/CR-3413 (*Off-Site Consequence of Radiological Accidents: Methods, Costs and Schedule for Decontamination*), 1984
- NUREG/CR-3566 (*Socioeconomic Consequences of Nuclear Reactor Accidents*), 1984
- NUREG/CR-3673 (*Economic Risks of Nuclear Power Reactor Accidents*), 1984

DO/HE

- NUREG/CR-6547 (*DOSFAC2 User's Guide*), 1997
- NUREG/CR-4214 (*Health Effects Model for Nuclear Power Plant Accident Consequence Analysis, Parts 1 and 2*), 1985
- NUREG/CR-4214, Rev 1, Part 1 (*Health Effects Model for Nuclear Power Plant Accident Consequence Analysis. Low LET Radiation. Part 1: Introduction, Integration and Summary*), 1990
- NUREG/CR-4214 Rev 1, Part 2 (*Health Effects Models for Nuclear Power Plant Accident Consequence Analysis. Low LET Radiation. Part 2. Scientific Bases for Health Effects Models*), 1989
- NUREG/CR-4214 Rev 1, Part 2, Addendum 1, LMF-132 (*Health Effects Model for Nuclear Power Plant Accident Consequence Analysis, Part2: Scientific Bases for Health Effects Models* - M*odifications of Models Resulting From Recent Reports on Health Effects of Ionizing Radiation: Low LET Radiation*), 1991
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